# PATENT ABSTRACTS OF JAPAN

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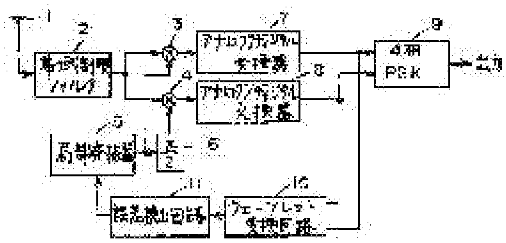
## (54) HIGH FREQUENCY FAST LEAD-IN SYSTEM APPLYING WAVELET TRANSFORMATION

(57)Abstract:

PURPOSE: To fast and accurately control the oscillation frequency of a local oscillator on a communication channel where a large frequency error is caused between a received signal and a local oscillation signal.

CONSTITUTION: The received signals are applied to the mixers 3 and 4, and the local oscillation signal of the sin wave generated by a local oscillator 5 is mixed with the local oscillation signal of a cosine wave transmitted from a phase shifter 6. These mixed signals are converted into the digital signals by the A/D converters 7 and 8, and the real and imaginary number parts are given to a wavelet transform circuit 10 to undergo the wavelet transformation. Then a frequency error is fast and accurately estimated by the circuit 11, and the oscillation frequency of the oscillator 5 is controlled so that the frequency error is reduced.



## CLAIMS

[Claim(s)]

[Claim 1]When having produced a big frequency error between an input signal and a local oscillation signal, A frequency high-speed drawing-in method using wavelet transform which controls frequency roughly for a short time when an error at the time of a drawing-in start is large, controls frequency correctly over many hours when an error is small, and is characterized by aligning said local oscillation signal with said input signal.

[Translation done.]

## DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application]In the case where this invention receives the signal from a satellite on the ground especially about the frequency high-speed drawing-in method which used wavelet transform, When the big frequency error has arisen between the input signal and the local oscillation signal, it is related with the frequency high-speed drawing-in method using the wavelet transform which presumes the frequency error and can follow.
[0002]
[Description of the Prior Art]In the communications system using a low-orbit satellite, in order that a satellite may go the earth around at high speed, when a terrestrial receiver receives the signal from a satellite, as for the signal, a channel receives a rapid large and Doppler frequency shift. Therefore, gross errors arise between the frequency of an input signal, and the oscillating frequency of the local oscillator which a receiver has, and the error is rapidly changed with time. Generally a receiver follows on being miniaturized, and in order for the local oscillator itself which a receiver has to have big frequency instability, even if a signal does not receive a frequency change with a channel, between the frequency of an input signal, and the oscillating frequency of the local oscillator of a receiver, gross errors produce it.
[0003]When a receiver performs synchronous detection in the channel which the big frequency error has produced between such an input signal and a local oscillation signal, in order to align the oscillating frequency of a receiver and a local oscillator with the frequency of an input signal, The frequency error between the input signal of a receiver and a local oscillation signal must be presumed at high speed and correctly, and the oscillating frequency of a local oscillator must be controlled so that the error becomes small. That is, it is necessary to draw frequency at high speed and correctly.
[0004]For the purpose, the crossing product type automatic-frequency-control method (a

crossing product algorithm is called), the automatic-frequency-control method (the Fast Fourier Transform algorithm is called) using Fast Fourier Transform, etc. are proposed from the former.

[0005]

[Problem(s) to be Solved by the Invention]There is a fault that an above-mentioned crossing product algorithm is the method of controlling the oscillating frequency of a local oscillator only by positive/negative of a frequency error, its drawing-in range of a frequency error is narrow, and frequency drawing in takes time too much for a long time. Although the Fast Fourier Transform algorithm of the drawing-in range of a frequency error is large on the other hand, since a trade-off is between frequency resolution and time resolution, It will draw, if the remains frequency error to which a remains frequency error will become large if drawing-in time is set up short is set up small, and there is a fault that time becomes long.

[0006]So, in the channel with which the big frequency error has produced the main purpose of this invention between the input signal and the local oscillation signal, It is providing the frequency high-speed drawing-in method using the wavelet transform which can control the oscillating frequency of a local oscillator so that the frequency error between an input signal and a local oscillation signal is presumed at high speed and correctly to a receiver and the error's becomes small.

[0007]

[Means for Solving the Problem]When having produced a big frequency error between an input signal and a local oscillation signal, an invention concerning claim 1, When an error at the time of a drawing-in start is large, frequency is controlled roughly for a short time, when an error is small, frequency is correctly controlled over many hours, and it is constituted so that a local oscillation signal may be aligned with an input signal.

[0008]

[Function]The frequency high-speed drawing-in method using the wavelet transform concerning this invention, Using the relation which is called wavelet and which carried out localization also in frequency also in time, time resolution uses the high feature with low frequency resolution that frequency resolution is high and time resolution's is low, so that frequency is conversely low, so that frequency is high, When the error at the time of a drawing-in start is large, frequency is controlled roughly for a short time, when an error is small, frequency is correctly controlled over many hours, and the frequency of a local oscillator is aligned with an input signal.

[0009]

[Example]First, before describing the example of this invention, the wavelet transform which is a principle of this invention is explained. Wavelet transform develops the inputted signal on a time-frequency flat surface. Prepare the function which is called a wavelet function and which

carried out localization also in frequency also in time, scale conversion and shift conversion are made to act on this, and the so-called group of a function is used for this deployment as a basis function.

[0010]How to choose a wavelet function has big flexibility mathematically, and localization is carried out to the frequency domain where the Fourier transform shown by the next ** (1) formula of basic wavelet function psi (t) which carried out localization to the limited time width around the starting point was restricted, If the ADOMISSHIBURU conditions (admissibility condition) furthermore given by the following ** (2) formula are fulfilled, it can choose arbitrarily.

[0011]

[Equation 1]

$$\hat{\Psi}(f) = \int dt\ \Psi(t) e^{-j2\pi ft} \qquad \cdots (1)$$

$$\hat{\Psi}(0) = \int_{-\infty}^{+\infty} \Psi(t) dt = 0 \qquad \cdots (2)$$

[0012]When a basic wavelet function is set to psi (t), after wavelet function $psi_{a\ and\ b}$ (t) carry out scale conversion of psi (t) a times, they are obtained by only b shifting the starting point. That is, wavelet function $psi_{a\ and\ b}$ (t) are given like the following ** (3) type.

[0013]

[Equation 2]

$$\Psi_{a,b}(t) = a^{-\frac{1}{2}} \Psi\left(\frac{t-b}{a}\right) \qquad \cdots (3)$$

[0014]Here, $a^{-1/2}$ is the normalization coefficients of the norm of $psi_{a\ and\ b}$ (t). a and b are called a scale parameter and a shift parameter, respectively, and express the reciprocal and time width of frequency of $psi_{a\ and\ b}$ (t).

[0015]The wavelet transform of signal g (t) using this wavelet function is defined by the following ** (4) type.

[0016]

[Equation 3]

$$g(a,b) = \int_{-\infty}^{+\infty} a^{-\frac{1}{2}} \Psi^{*}\left(\frac{t-b}{a}\right) g(t)\ dt \qquad \cdots (4)$$

[0017]From an above-mentioned ** (4) type, the basic wavelet function psi (t) has a value only in the range of $t_1$<=t<=$t_2$ and $f_1$<=f<=$f_2$ in a segment of time and a frequency domain,

respectively, In other fields, supposing it is close to 0 enough, wavelet function psi$_{\text{a and b}}$ (t) will take charge of the range of b+at$_1$<=t<=b+at$_2$ and f$_1$/a<=f<=f$_2$/a, and the ingredient of g (t) of this range will be contained in g (a, b).

[0018]It can be realized to all the combination of the parameters a and b that wavelet transform takes correlation using wavelet function psi$_{\text{a and b}}$ (t). Considering carrying out digital processing of the signal, it is necessary to treat discretely the wavelet transform shown in the ** (4) type. Each wavelet transform defines a time-frequency flat surface for a scale parameter and a shift parameter as a wrap sake like the following ** (5) type without a crevice, respectively. However, n and l are integers. At this time, discrete wavelet transform is defined like a ** (6) type.

[0019]

[Equation 4]

$$a = 2^n,\ b = l2^n \qquad \cdots (5)$$

$$g_{n,l} = \sum_{k=-\infty}^{+\infty} \Psi^*_{n,l}(kT)\ g\ (kT)$$

$$= \sum_{k=-\infty}^{+\infty} 2^{-\frac{n}{2}}\ \Psi^*\left(\frac{kT - 2^n l}{2^n}\right) g\ (kT) \qquad \cdots (6)$$

[0020]However, T expresses sampling time intervals. g$_{\text{n and k}}$ are called a wavelet coefficient and become a coefficient when g (t) is developed by psi$_{\text{n and l}}$ (kT) like a ** (7) type.

[0021]

[Equation 5]

$$g(t) = C_\Psi^{-1} \sum_{n,l} g_{n,l}\ \Psi_{n,l}\ (t) \qquad \cdots (7)$$

[0022]

[External Character 1]

ただし、$C_\Psi^{-1}$ はウェーブレット関数$\Psi_{n,l}(kT)$ によって決定される定数である。

[0023]Drawing 1 is a figure showing the time and frequency resolution in a time-frequency flat surface of wavelet transform and short time Fourier transformation. It turns out that the short time Fourier transformation shown in drawing 1 (b) serves as the same temporal modulation resolution in every field on a time-frequency flat surface. On the other hand, frequency resolution is high also on frequency with low wavelet transform shown in drawing 1 (a), and time resolution is low. On the other hand, on high frequency, frequency resolution is low and

time resolution is high. This follows the uncertainty principle of the time and frequency that short time Fourier transformation or wavelet transform also has a constant area of each rectangle shown in drawing 1. By the way, the point which it must be careful of is using the wavelet transform which can discriminate negative frequency from positive, in order that the frequency error between an input signal and a local oscillation signal may take a positive and negative value. When the Haar function is used as a basic wavelet function, the complex Haar function which extended the Haar function to the complex number so that negative frequency could be discriminated from positive is explained below.

[0024]Drawing 2 is a figure showing the relation between the Haar function and its power spectral density. the wavelet function form obtained from the Haar function -- {psi$_{n,\ l}$|psi$_{n,\ \mathrm{and}\ l}$ (t) |=2$^{-1/2}$psi (2$^{-n}$t-l)} makes an orthonormal system, and when wavelet transform is performed, it becomes orthogonal expansion. It is possible by performing reverse wavelet transform to reproduce the signal of a basis.

[0025]In the wavelet transform using the Haar function, since power spectral density |psi(f) |$^2$ of the Haar function is an even function about the frequency f like a ** (8) type, the frequency component of positive/negative will be simultaneously contained in one wavelet coefficient.

[0026]

[Equation 6]

$$|\Psi(f)|^2 = \left(\frac{\sin \pi f/2}{\pi f/2}\right)^2 \sin^2 \frac{\pi f}{2} \qquad \cdots (8)$$

[0027]Drawing 3 is a figure showing a complex Haar function and its power spectral density. Here, in order to distinguish the frequency of positive/negative, the complex Haar function which carried out complexification of the Haar function as shown in drawing 3 shall be proposed, and, below, the wavelet transform by a complex Haar function shall be considered. Although the real component of a complex Haar function is the same as that of the Haar function, an imaginary component carries out the phase shift of the Haar function only pi/2. The real component and the imaginary component have normalized amplitude, respectively so that it may be set to ||psi(t) ||$^2$=1. Power spectral density |psi(f) |$^2$ of a complex Haar function becomes like a ** (9) type.

[0028]

[Equation 7]

$$|\hat{\Psi}(f)|^2 = \left(\frac{\sin \pi f/2}{\pi f/2}\right)^2 \left(1 - \cos \frac{\pi f}{2}\right)\left(1 + \sin \frac{\pi f}{2}\right) \qquad \cdots (9)$$

[0029]This ** (9) type shows having a basic component focusing on the positive frequency f= 1 [Hz].

[0030]When the complex Haar function psi (t) is made into a basic wavelet function, wavelet deployment and the wavelet coefficient of signal g (t) are given with a following formula.
[0031]
[Equation 8]

$$g(t) = \sum_{\sigma,n,l} g_{n,l}^{(\sigma)} \Psi_{n,l}^{(\sigma)}(t) \quad \cdots (10)$$

$$g_{n,l}^{(\sigma)} = \sum_{x,n,l} \Psi_{n,l}^{(\sigma)*}(kt)\, g(kt)\, dt \quad \cdots (11)$$

$$\Psi_{n,l}^{(\sigma)}(t) = 2^{-\frac{n}{2}} \Psi^{(\sigma)}(2^{-n}t - l)$$

$\sigma = +,\ -;\ n,\ l$ は整数

$$\Psi^{(+)}(t) = \Psi(t),\ \Psi^{(-)}(t) = \Psi^{*}(t)$$

[0032]
[External Character 2]
ウェーブレット係数$g_{n,k}^{(\sigma)}$は、時刻$t = 2^n \cdot k$,周波数$f = \sigma \cdot 2^{-n}$の成分を表わす。

[0033]Based on having stated above, a peak search method and a stabilimeter algorithm are explained below as an estimation algorithm of a frequency error using wavelet transform.
[0034]First, when it searches for a peak toward a low-frequency component from a high frequency component in a wavelet coefficient and some certain conditions are fulfilled by a peak search method, the frequency is outputted as error frequency. If the frequency of a local oscillator is updated at this time, on the whole, the power spectrum newly obtained will move only the part of that frequency. Therefore, all wavelet circuits are reset and it is necessary to recalculate from the start in the case of renewal of the frequency of a local oscillator.
[0035]Drawing 4 is a figure showing the algorithm of a peak search method. In drawing 4, in step (in graphic display, it is called SP for short) SP1, it is distinguished whether there is any renewal of a wavelet coefficient, if there is updating, it will progress to step SP2, and if there is no updating, it will progress to step SP7. Maximum search is performed in step SP2. That is, three are searched at a time sequentially from what has a large absolute value of a wavelet coefficient about each of a positive/negative frequency component. Each is made into $c_1^{(+)}$ and $c_2^{(+)}$, $c_3^{(+)}$ and $c_1^{(-)}$, and $c_2^{(-)}$ and $c_3^{(-)}$. Next, a peak judging is performed in step SP3. That is, if either of the $c_1^{(+)}$ and $c_1^{(-)}$ is an ingredient of low frequency most at present, it will progress to step SP7, otherwise, will progress to step SP4. It is distinguished, and if it is 4 or

less-time frequency whether it is 4 or less times [ of frequency errors other than zero to which the frequency of the peak searched in step SP4 was outputted last time ] frequency, it will progress to step SP5. a step -- SP -- five -- setting -- a peak -- a sufficient condition -- judging -- having -- | -- c -- $_{1}{}^{\text{-- (-- + --) --}}$ -- /-- c -- $_{1}{}^{\text{-- (-) --}}$ -- | -- > -- one . -- 85 -- | -- c -- $_{1}{}^{\text{-- (-- + --) --}}$ -- /-- c -- $_{3}{}^{\text{-- (-- + --) --}}$ -- | -- > -- 2.85 -- both -- filling -- having -- if. Frequency with the coefficient of $c_1^{(+)}$ is outputted as a frequency error. moreover -- | -- c -- $_{1}{}^{\text{-- (-) --}}$ -- /-- c -- $_{1}{}^{\text{-- (-- + --) --}}$ -- | -- > -- one . -- 85 -- | -- c -- $_{1}{}^{\text{-- (-) --}}$ -- /-- c -- $_{3}{}^{\text{-- (-) --}}$ -- | -- > -- 2.85 -- both -- filling -- having -- if. Frequency with the coefficient of $c_1^{(-)}$ is outputted as a frequency error, and if it is except it, 0 will be outputted as a frequency error. In step SP6, when frequency errors other than zero are outputted, all the old data of a wavelet conversion circuit is reset. And it progresses to the next sample time in step SP7. The threshold 1.85-2.85 is a value calculated experientially. Although a local peak may appear in a high frequency component by noise etc. and a step-out may happen in wavelet transform, It is made to progress to step SP5 only when it is 4 or less times [ of frequency errors other than zero to which the frequency of the searched peak was outputted last time ] frequency, as the above-mentioned step SP4 described.

[0036]Although it can only perform detecting the sampled discrete frequency by a peak search method like ****, a frequency error can be presumed in more detail by calculating the center of gravity of a wavelet coefficient. Calculation of the center of gravity is performed at every output of a new wavelet coefficient, and the frequency of a local oscillator is updated. At this time, since the wavelet coefficient of a low-frequency component has low time resolution, chain calculation time is required. Therefore, since calculation of a low-frequency component will no longer be performed like a peak search method if a wavelet circuit is reset for renewal of the frequency of a local oscillator, it is necessary not to perform reset of a wavelet circuit.

[0037]However, since a power spectrum is changed for renewal of the frequency of a local oscillator, a new value is not necessarily obtained by the wavelet coefficient of low frequency components. Therefore, it is necessary to smooth the frequency of the calculated center of gravity and to output it to a local oscillator.

[0038]Drawing 5 is a flow chart showing the algorithm of a stabilimeter algorithm. In step SP11 of drawing 5, it is distinguished whether there is any renewal of a wavelet coefficient, if there is updating, it will progress to step SP12, and if there is no updating, it will progress to step SP14. Center-of-gravity calculation is performed in step SP12. That is, frequency $f_e$ of the center of gravity is calculated like a ** (12) type from distribution of a wavelet coefficient.

[0039]

[Equation 9]

$$\hat{f}_e(kT) = \frac{\Sigma_{n,\sigma}\ \sigma \cdot 2^{-n} \cdot |g_n^{(\sigma)}|^2}{\Sigma_{n,\sigma}\ |g_n^{(\sigma)}|^2} \qquad \cdots (12)$$

$$(x = +,\ -)$$

[0040]However, wavelet coefficient $g^{(x)}_n$ uses the newest thing obtained at present. In step SP13, frequency $f_e$ of the calculated center of gravity is inputted into the smoothing filter calculated with the recurrence formula showing in a ** (13) type, and $f_O$ (kT) is outputted as a frequency error.

[0041]

[Equation 10]

$$f_o(kT) = f_o((k-1)\ T) + \alpha_f \cdot \frac{\hat{f}_e(kT)}{4} \qquad \cdots (13)$$

$$(\alpha_f \text{ は定数, } 0 < \alpha_f < 1)$$

[0042]And in step SP14, it progresses at the next sample time. Drawing 6 is a block diagram of one example of this invention. In drawing 6, if a signal is received by the antenna 1, an input signal will be band-limited by the band limit filter 2, and will be given to the mixers 3 and 4. The local oscillation signal of the sin wave oscillated with the local oscillator 5 is given to the mixer 3, and is mixed with an input signal. By the phase converter 6, the local oscillation signal of a sin wave is shifted pi/2, and is given to the mixer 4 as a local oscillation signal of a cos wave. The output of the mixers 3 and 4 is the inphase and quadrature component in low-pass of an input signal, respectively, and serves as real part of the complex input to the wavelet conversion circuit 10, and an imaginary part using a complex Haar function. Each mixed output is given to the analog-to-digital conversion machines 7 and 8, and is changed into a digital signal, and the digital signal is given to the 4 phase PSK circuit 9 and the wavelet conversion circuit 10. A 4 phase PSK circuit restores to a digital signal, wavelet transform of the wavelet conversion circuit 10 is carried out using a complex Haar function, an error is detected by the error detector circuit 11 and the oscillating frequency of the local oscillator 5 is updated.

[0043]How the receiver constituted like drawing 6 estimates the frequency drawing-in characteristic of the estimation algorithm of the frequency error in the invention in this application by computer simulation is explained. The additivity Gaussian random noise (AWGN) channel with which a frequency error exists as a channel shall be assumed, and phasing shall not be taken into consideration. An initial frequency error performs 10 kHz and a sampling frequency performs computer simulation as 288 kHz.

[0044]Drawing 7 is a graph of infinity [dB] (with no noise) about energy ratio $E_s/N_o$ of the signal

per specimen, and noise, Drawing 8 is a graph about the case where it is referred to as 15 [dB] and 10 [dB], and drawing 9 shows the graph of the frequency error (effective value in 30 trial frequency) over sample size (time).

[0045]Here, filter factor alpha$_f$ in a stabilimeter algorithm was set to 0.01. The characteristic at the time of using the case where a crossing product algorithm is used instead of wavelet conversion algorithms, and the Fast Fourier Transform algorithm of 1024 points, as a standard of evaluation is also shown collectively.

[0046]When a crossing product algorithm is used, drawing in takes time too much and a frequency error does not become small easily. A remains frequency error is also still large. On the other hand, when the Fast Fourier Transform algorithm is used, as it is shown in time and frequency resolution is shown in drawing 1, it is fixed in every field on a time-frequency flat surface. Therefore, when the speed of initial frequency level luffing motion is required, frequency resolution falls and exact frequency drawing in becomes impossible. On the contrary, when exact frequency drawing in is required, time resolution will fall and initial frequency drawing in will become late.

[0047]Compared with the case where a crossing product and the Fourier conversion algorithms are used by a peak search method on the other hand, since the time resolution of a high frequency component is high, drawing in is quick. Since the small frequency error which cannot be distinguished in the case where a crossing product and the Fast Fourier Transform algorithm are used by lengthening observed time is detectable, a remains frequency error becomes small.

[0048]In a stabilimeter algorithm, since the estimated frequency error is smoothed, initial drawing in is considerably late for a peak search method, but it can be improved by this by enlarging filter factor alpha$_f$.

[0049]

[Effect of the Invention]As mentioned above, when having produced the big frequency error between the input signal and the local oscillation signal according to this invention, When the error at the time of a drawing-in start is large, frequency can be controlled roughly in a short time, when an error is small, frequency can be correctly controlled over many hours, and a local oscillation signal can be aligned with an input signal. If it is made to operate still longer, an error can be made small without limit.

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[Translation done.]

## TECHNICAL FIELD

[Industrial Application]In the case where this invention receives the signal from a satellite on the ground especially about the frequency high-speed drawing-in method which used wavelet transform, When the big frequency error has arisen between the input signal and the local oscillation signal, it is related with the frequency high-speed drawing-in method using the wavelet transform which presumes the frequency error and can follow.

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## PRIOR ART

[Description of the Prior Art]In the communications system using a low-orbit satellite, in order that a satellite may go the earth around at high speed, when a terrestrial receiver receives the signal from a satellite, as for the signal, a channel receives a rapid large and Doppler frequency shift. Therefore, gross errors arise between the frequency of an input signal, and the oscillating frequency of the local oscillator which a receiver has, and the error is rapidly changed with time. Generally a receiver follows on being miniaturized, and in order for the local oscillator itself which a receiver has to have big frequency instability, even if a signal does not receive a frequency change with a channel, between the frequency of an input signal, and the oscillating frequency of the local oscillator of a receiver, gross errors produce it.
[0003]When a receiver performs synchronous detection in the channel which the big frequency error has produced between such an input signal and a local oscillation signal, in order to align the oscillating frequency of a receiver and a local oscillator with the frequency of an input signal, The frequency error between the input signal of a receiver and a local oscillation signal must be presumed at high speed and correctly, and the oscillating frequency of a local oscillator must be controlled so that the error becomes small. That is, it is necessary to draw frequency at high speed and correctly.
[0004]For the purpose, the crossing product type automatic-frequency-control method (a crossing product algorithm is called), the automatic-frequency-control method (the Fast Fourier Transform algorithm is called) using Fast Fourier Transform, etc. are proposed from the former.

[Translation done.]

## EFFECT OF THE INVENTION

[Effect of the Invention]As mentioned above, when having produced the big frequency error between the input signal and the local oscillation signal according to this invention, When the error at the time of a drawing-in start is large, frequency can be controlled roughly in a short time, when an error is small, frequency can be correctly controlled over many hours, and a local oscillation signal can be aligned with an input signal. If it is made to operate still longer, an error can be made small without limit.

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## TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention]There is a fault that an above-mentioned crossing product algorithm is the method of controlling the oscillating frequency of a local oscillator only by positive/negative of a frequency error, its drawing-in range of a frequency error is narrow, and frequency drawing in takes time too much for a long time. Although the Fast Fourier Transform algorithm of the drawing-in range of a frequency error is large on the other hand, since a trade-off is between frequency resolution and time resolution, It will draw, if the remains frequency error to which a remains frequency error will become large if drawing-in time is set up short is set up small, and there is a fault that time becomes long.
[0006]So, in the channel with which the big frequency error has produced the main purpose of this invention between the input signal and the local oscillation signal, It is providing the frequency high-speed drawing-in method using the wavelet transform which can control the oscillating frequency of a local oscillator so that the frequency error between an input signal and a local oscillation signal is presumed at high speed and correctly to a receiver and the error's becomes small.

[Translation done.]

## MEANS

[Means for Solving the Problem]When having produced a big frequency error between an input signal and a local oscillation signal, an invention concerning claim 1, When an error at the time of a drawing-in start is large, frequency is controlled roughly for a short time, when an error is small, frequency is correctly controlled over many hours, and it is constituted so that a local oscillation signal may be aligned with an input signal.

[Translation done.]

* NOTICES *



1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

## OPERATION

[Function]The frequency high-speed drawing-in method using the wavelet transform concerning this invention, Using the relation which is called wavelet and which carried out localization also in frequency also in time, time resolution uses the high feature with low frequency resolution that frequency resolution is high and time resolution's is low, so that frequency is conversely low, so that frequency is high, When the error at the time of a drawing-in start is large, frequency is controlled roughly for a short time, when an error is small, frequency is correctly controlled over many hours, and the frequency of a local oscillator is aligned with an input signal.

[Translation done.]

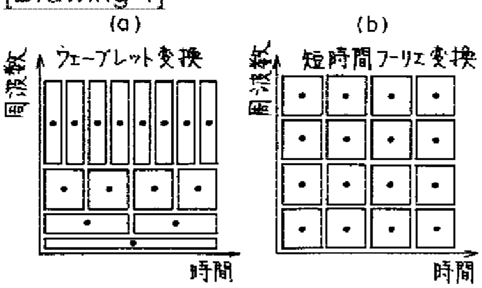
## DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]It is a figure showing the time and frequency resolution in a time-frequency flat surface of wavelet transform and short time Fourier transformation.
[Drawing 2]It is a figure showing the Haar function and its power spectral density as a basic wavelet function.
[Drawing 3]It is a figure showing a complex Haar function and its power spectral density.
[Drawing 4]It is a flow chart for explaining a peak search method.
[Drawing 5]It is a flow chart for explaining a stabilimeter algorithm.
[Drawing 6]It is a block diagram of one example of this invention.
[Drawing 7]It is a figure showing the frequency drawing-in characteristic when a frequency offset in case there is no noise is constant.
[Drawing 8]It is a figure showing the frequency drawing-in characteristic when a frequency offset in case a signal-to-noise energy ratio is 15 [dB] is constant.
[Drawing 9]It is a figure showing the frequency drawing-in characteristic when a frequency offset in case a signal-to-noise energy ratio is 10 [dB] is constant.
[Description of Notations]
1 Antenna
2 Band limit filter
3 and 5 Mixer
5 Local oscillator
6 Phase converter
7, 8 analog-to-digital-conversion machine
9 4 phase PSK
10 Wavelet conversion circuit
11 Error detector circuit

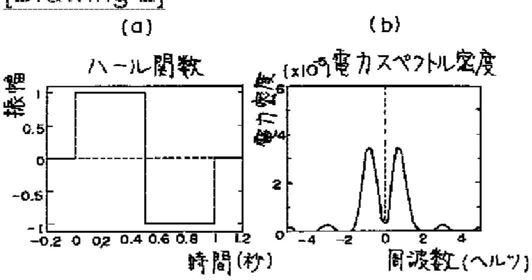
[Translation done.]

## DRAWINGS

[Drawing 1]

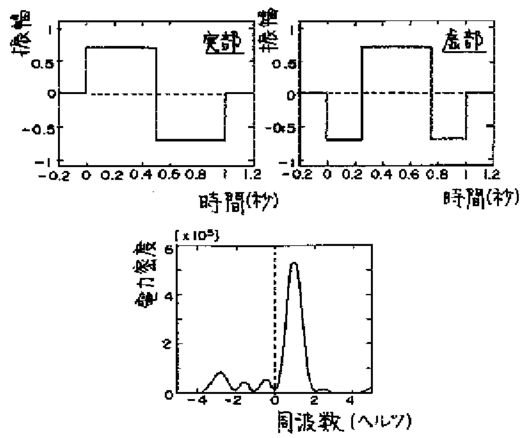



[Drawing 2]

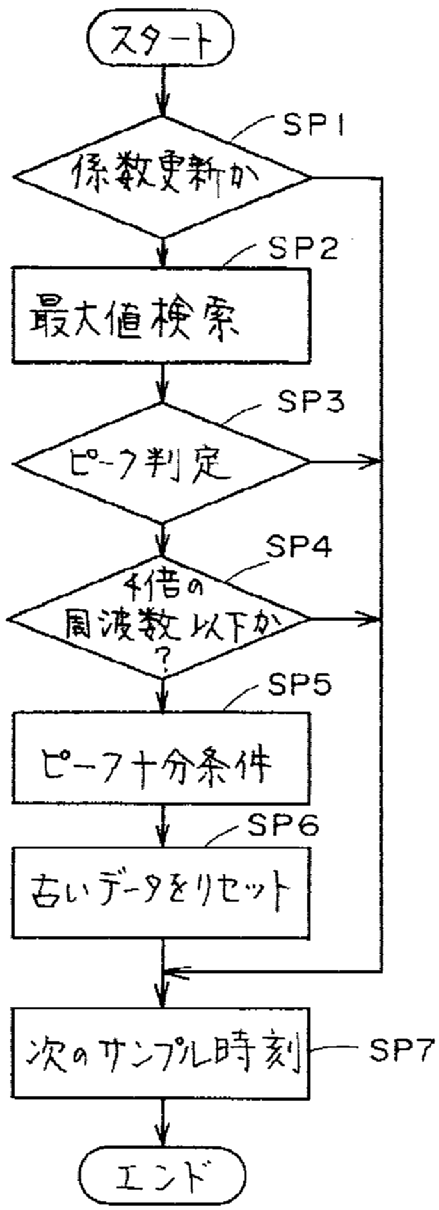



[Drawing 3]

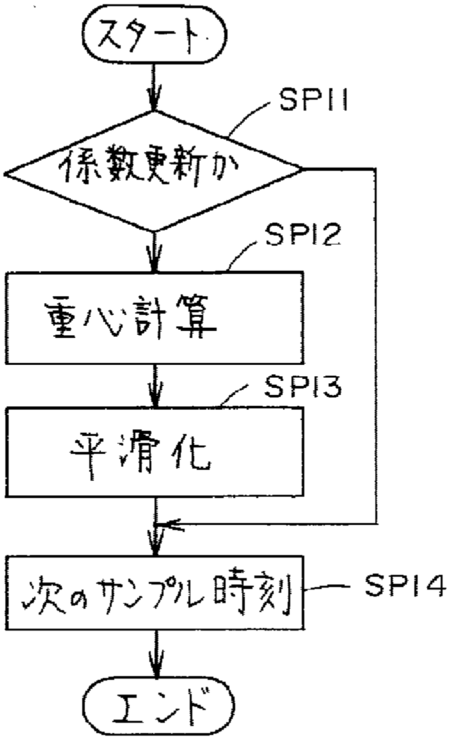
(a) 複素ハール関数



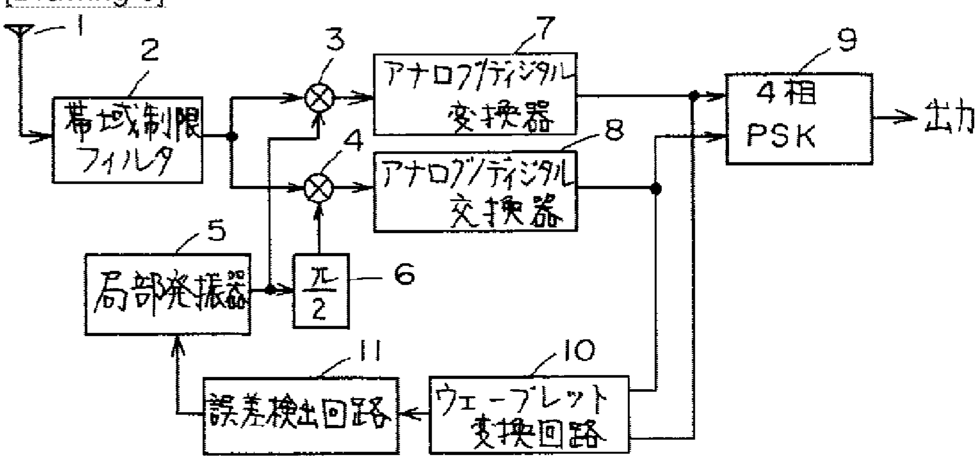

[Drawing 4]



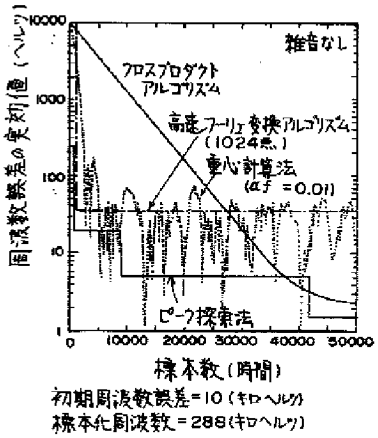
[Drawing 5]



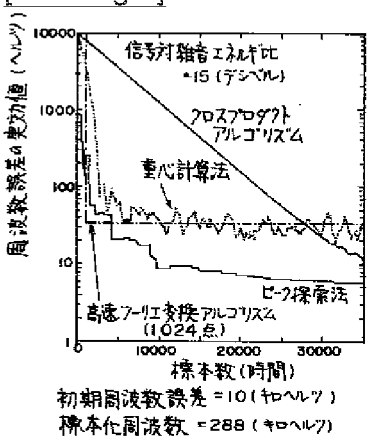

[Drawing 6]



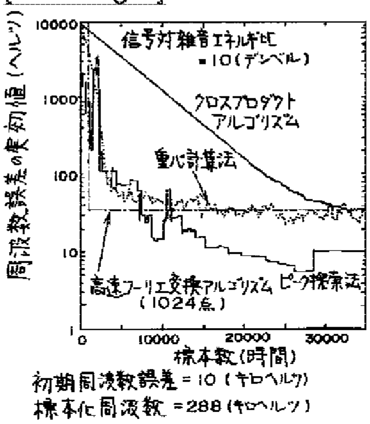

[Drawing 7]




[Drawing 8]




[Drawing 9]




[Translation done.]